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ART XII.—*The Physiography of the Gisborne Highands.*

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Introduction.

In this paper the writer accepts the view, which he believes to be in accord with that of most physiographers, that in Australia during Tertiary times at least, one long erosion period occurred, in which much of the continent, including the area here dealt with, was reduced to a state of mature erosion or of peneplanation. An attempt is here made to trace the physiographic history of the area from this early erosion period, or if there was more than one, from the latest erosion period to the present day. The contoured maps of the Military Survey have been used for fixing altitude in part of the area. Elsewhere heights were measured differentially by aneroid, and are therefore only approximate. In some cases a sight level was used.

The names adopted are chiefly those in local use. One Mile Creek and Fisher's Creek are names used in the early days of settlement. Unnamed features which it has been necessary to refer to have, in most cases, been given the name of an adjoining landholder, as Hassed's Creek. Jackson's Creek is the name adopted by the Country Roads Board for the main stream of the district, which on the Quarter Sheet is called the Macedon or Saltwater River. Of this creek, the West Macedon branch, which comes from the north, is regarded as the main stream; the western branch is the Slate Quarry Creek. Hassed's Creek is a smaller tributary which runs parallel to the Bacchus Marsh road. The Newer Volcanic lavas are here referred to collectively as basalt.

EXTENT AND GENERAL DESCRIPTION OF THE AREA.

The area dealt with extends from the line of differential movement about 8 miles south of Gisborne, named by Fenner (1918) the "Gisborne Fault," to the Main Divide of Victoria in the north, and from the Rowsley Fault in the west, to a few miles east of Gisborne, as shown in Fig. 1.

The rocks represented consist of slates, shales, quartzites and sandstones of Ordovician age, gravels and conglomerates marked Older Pliocene on the Quarter Sheet, Newer Volcanic lava flows, and Recent Alluvium. A quartz-felspar dyke outcrops east of Cockatoo Gully, and another, decomposed to a white clay, near the Slate Quarry, about 6 miles west of Gisborne. At least two east-west dykes, 3 or 4 feet in width and decomposed to a soft brown clay, are exposed in the bed of the Pyrete Creek, east of Mt. Bullengarook and Haire's Hill.

Ordovician rocks prevail in the western portion of the area. Towards the south they are deeply dissected by Goodman's and the Pyrete Creeks and their tributaries. Mt. Bullengarook, 2207 feet, and Haire's Hill are volcanic hills. From Mt. Bullengarook long tongues of lava run south towards Bacchus Marsh, and north-west towards Gisborne. Much of this western area is Crown land, at present of commercial value, chiefly for saw-milling purposes. A slate quarry was worked many years ago, and was re-opened for a time during the war of 1914-1918. Alluvial gold occurs in small amount; the richest locality seems to have been about 5 miles south of Mt. Bullengarook, at Cockatoo Gully, which has cut into the gravel underlying the basalt. The late Mr. William Thom, in a personal communication to the writer, stated that the largest nuggets found in the district weighed respectively 36 oz., 17 oz., and 12 oz. All were found southward of Mt. Bullengarook. To the east of Gisborne township is an area of rich agricultural land in which the old surface features are almost entirely obscured by the Newer Volcanic lava flows. The north peak of Mt. Gisborne, 2,105 feet, is the highest point. The northern portion of the area is drained by Jackson's Creek, and the southern portion by tributaries of the Werribee River and the Kororoit Creek.

PREVIOUS WORK.

The eastern portion of the area is included in Quarter Sheets 6 S.E. and 7 N.W., and these sheets remain the best guide to the area covered by them. However, some modifications are called for, and will be referred to as occasion arises.

Fenner (1) included the area, under the name of the "Gisborne Highlands," in his paper on the physiography of the Werribee area. He attributed the abrupt change of level between the Gisborne block and the Werribee plains to an east and west fault which he named the "Gisborne Fault," and on the evidence of the contour maps, he pointed out the probability that the head gullies of the Djerriwarrh Creek had been captured by the Pyrete Creek.

In 1920 W. J. Harris and the writer published a paper (2) dealing chiefly with the sedimentary rocks of the Gisborne district, in which it was shown that the bedrock of the area is of Ordovician age. On the evidence of graptolites, an important fault was shown to exist at the Djerriwarrh Creek, and agreement was expressed with Dr. Fenner regarding the probability of stream capture. Dunn's Gully (see Fig. 1) was erroneously marked "Cataract Gully" on the map accompanying that paper. Cataract Gully is the gully running south from Mt. Bullengarook over the basalt.

The Bullengarook Gravels.

On Quarter Sheets 6 S.E. and 7 N.W. several small areas of gravel and conglomerate are shown between Gisborne and Little Bullengarook or, as it is usually called, Haire's Hill. These sub-basaltic gravels and conglomerates are, however, much more extensive and continuous than the Quarter Sheets indicate. Their eastern limit, as far as can be seen, is in Aitken-street, Gisborne, near the Presbytery. On the Calder Highway, about a quarter mile north of the bridge over Jackson's Creek, sub-basaltic gravel which may be an outlying portion of the old gravels occurs. The northern boundary of the gravels runs from Gisborne along Jackson's Creek and the Slate Quarry Creek, to some distance west of the slate quarry. Near the junction of the Slate Quarry Creek and Jackson's Creek, the gravel extends somewhat further north to about half a mile north-west of the junction of the creeks. The western boundary runs south from the Slate Quarry Creek towards Mt. Bullengarook. For the greater part, this boundary is not clearly defined, but at Carrol's Lane the gravels are somewhat sharply cut off, probably by the erosion of Goodman's Creek. Some prospecting has been done here in the gravel, and if we may take the vertical distance between the lowest gravel in a prospector's shaft, and the highest gravel on the lane about 150 yards away, to be the thickness of the gravel sheet, it must have been not less than 60 or 70 feet at this point.

Gravel occurs on the northern flank of Mt. Bullengarook, and surrounds Haire's Hill except perhaps on the west side. From Haire's Hill the gravel boundary runs east and north-east to Gisborne. Within a few miles of Haire's Hill tributaries of the Pyrete Creek have cut into the gravel, and on the more level ground towards Gisborne it is difficult to define the boundary between the gravels and sands and the soil derived from the Ordovician bedrock. Several outlying patches of conglomerate occur as far south as Slocomb's Corner. The extreme dimensions of the gravel area are about 7 miles east to west by 4 miles north to south. A good section of the gravel is to be seen in a pit near Dohoney's Corner. Most of the material here is of a sandy nature, mottled red, and showing well marked current bedding. Occasional beds occur in which the pebbles and boulders range to more than 18 inches in diameter. On the roadside near the gravel pit a shaft has been sunk through gravel to bedrock, and the vertical distance from the bottom of the shaft to the top of the gravel-capped hill above the pit is between 60 and 70 feet. Throughout the gravels, except perhaps at the extreme eastern occurrence, large boulders occur intermingled with the finer material. On the road a mile north-west of Dohoney's Corner, rounded boulders nearly 2 feet long occur. West of Mt. Bullengarook some are at least 1 foot long, and at Slocomb's Corner and near Brucedale they may be 9-10 inches long. The pebbles and boulders consist of reef quartz, quartzite, sandstone, and very rarely of soft shaly material. They range from angular to completely rounded. No igneous pebbles have so far been found, and none which show any trace of glacial action.

Within about 2 miles of its northern edge the gravel has the form of a sheet, covering the bedrock entirely except where intersected by the basalt-filled valleys of old streams. At Slocomb's Corner and at Gisborne it occupies lower ground, with the bedrock rising up to 50 feet above it.

The contrast between the low, gravel-covered right banks of Jackson's and the Slate Quarry Creeks and their high, steep left banks of Ordovician rocks might suggest faulting. However, the highest gravel near Dohoney's Corner and at Mt. Bullengarook is almost equal in height to the Ordovician towards the north, and it is probable that the appearance of faulting is entirely due to erosion by these creeks. The northern edge of the gravel sheet is some 4 or 5 miles south of the main divide. About the same distance to the north of the divide, sub-basaltic gravel occurs near Woodend (5). As far as the writer is aware no gravel of similar age occurs between these points.

SOURCE OF THE GRAVEL.

The nature and distribution of the gravel show that its source was to the north, that is in the direction of the present main divide. This implies uplift in that direction, with a change of grade at the northern edge of the gravel sheet. At the present day the heaviest floods do no more than move the existing gravel along the beds of the creeks, and deposit a little silt on some of the river flats. It seems, therefore, that in the production of the gravel, uplift was associated with torrential floods far exceeding any experienced at the present day. There seem to have been at first no definite drainage lines, but the gravel appears to have been swept down in a sheet, or by a number of minor torrents, and spread out on reaching the lower grade, the flood water making its way eastward by Gisborne, south-west by Mt. Bullengarook, and southward by Slocomb's Corner.

The Old Erosion Surface.

As indicated, the Bullengarook Gravel sheet seems to have completely covered the bedrock over a considerable area, and since any differential movement would tend, from its inception, to produce greater surface relief, the old erosion surface in that area was not more uneven than that preserved under the comparatively thin gravel sheet.

It is reasonable to suppose that any wide level Ordovician area on the divides or elsewhere, where denudation is extremely slow, will at present show surface features resembling those of the old erosion surface. Probably the nearest approach to such an area lies immediately to the west of Gisborne, between the Bacchus Marsh and Melton roads. Even this area, with its low rounded hills and shallow, grassy gullies, is, owing to its proximity to the valley of Jackson's Creek, probably much more uneven than the more level parts of the old erosion surface.

Besides extensive level tracts, there seem to have been prominent hills and ridges rising conspicuously above the general level. On the western slope of Mt. Gisborne, bedrock occurs at a height of about 1,750 feet, which is 200 feet above that on the Melton road, less than half a mile away, and a ridge of bedrock in part covered by basalt extends north-east from that point to Gisborne. This ridge was of no great width, because towards the east no bedrock is exposed at the surface for more than 2 miles, and a bore put down on the north-west slope of Mt. Gisborne, about the 1,900 feet contour, penetrated a depth of 345 feet through basalt to bedrock. It seems clear that this ridge of bedrock existed at the time of the deposition of the Bullengarook gravel, and that it greatly influenced the drainage both at that time and later. There seems to have been high bedrock also at Mt. Bullengarook and at Red Rock. Mt. Tophet, with the broken ridge of bedrock running towards the north across the Calder Highway, was probably a prominent feature of the old surface.

The writer pictures the old erosion surface towards the end of the erosion period as consisting of wide, almost flat areas with here and there prominent hills and ridges, and at wider intervals still higher and older mountain masses such as the Macedon Ranges.

At Gisborne and at Slocomb's Corner, where outliers of gravel and conglomerate exist in valleys between low hills, some of the unevenness of surface may be due to denudation while the gravel was being laid down.

Differential Movement in the South of the Area.

Fenner attributed the abrupt change of level in the south of the area, largely on physiographic evidence, to a fault which he named the "Gisborne Fault" (1). Being unable to trace any distinct line, especially towards the west, which might with confidence be regarded as the line of a major fault, the writer prefers to refer to it as a line of differential movement.

The Age of the Movement Relative to the Main Divide.

If considerable differential movement had taken place on this line at the time of the deposition of the Bullengarook gravels, it might have been expected that similar gravels would also have formed on the lower block. The only locality where sub-basaltic water-worn gravel, which may be regarded as being on the lower block, has been noticed by the writer is near Coimadai, where there is little doubt, it has been brought down by the "Ancient Bullengarook River," and in part derived from the pre-existing gravel of Bullengarook.

Quarter Sheet 7 N.W. shows several small areas of Older Pliocene gravel, etc., near the Toolern Creek. Of these, all which lie to the north of Breakneck Hill are silicified bedrock or surface breccia. It is especially important to note that the small patch shown in the bottom of the gully close to Breakneck Hill is bedrock, and is not in the bottom of the gully but about 50 feet above.

A mile south-east of Breakneck Hill there is on the Quarter Sheet the note "Hard Crystalline Conglomerate". This rock can be traced back over a considerable area to the west of Toolern Creek, and across the Melton road. It is an extremely hard rock in which the original structure is hardly discernible. However, in places numerous small fragments of quartz and quartzite may be seen, and these are quite angular. It probably consists of material drifted or washed from the slopes, and subsequently metamorphosed by the lava, and probably resembled the "drift" which overlies the basalt near Sunbury (3). It might be thought that the wide, low-lying stretch of country where it occurs is the result of erosion. Its width, however, makes this unlikely, especially if, as is probable, the eastern branch of the Toolern Creek came into existence after the commencement of the Newer Volcanic period; and it seems more probable that it is the result of differential movement. The nature of this "Conglomerate" indicates that it was formed under climatic conditions differing from those that prevailed during the formation of the Bullengarook gravel, and similar to that of recent times, so that the differential movement is of later date than the uplift of the main divide. This conclusion is supported by the more mature erosion of the northern area in comparison with that bordering the southern edge of the Gisborne block.

AGE OF THE DIFFERENTIAL MOVEMENT RELATIVE TO THE NEWER BASALT.

The infilled valley of the old Toolern Creek was several hundred feet deep where it crossed from the higher to the lower block early in the Newer Volcanic period, and the infilling lava shows no sign of disturbance, so that the differential movement was probably complete at the commencement of the Newer Volcanic period.

DIRECTION AND NATURE OF THE MOVEMENT.

From the Rowsley Fault the line of differential movement runs in a generally easterly direction for about 10 miles to Toolern Vale, where it turns north and apparently dies out in a few miles. While the general direction of the line of movement is as stated, considerable irregularities exist, especially near Toolern Vale. On evidence which like that obtained by Dr. Fenner is largely physiographic, it is suggested that the north and south portions of the movement, and part of the east and west portion near Toolern Vale, are due to simple faulting, but towards the west the movement is more complicated, with step faulting and monoclinal folding, the Coimadai fault being part of the main movement. The greatest elevation along the southern edge of the Gisborne block is north of Toolern Vale at Black Hills, 1,550 feet. It is noticeable that the Ordovician of the Black Hills to the east, and near Breakneck Hill to the west of the valley of the old Toolern Creek, is considerably higher than the basin of the old stream. This greater elevation suggests two interesting possibilities: a ridge of Ordovician through a low gap in which the old Toolern Creek found an outlet may have existed in the old erosion surface, or the differential uplift may have been greatest near the southern edge of the uplifted block, giving it a tilt towards the north.

The Pre-Basaltic Streams.

The grade of the pre-basaltic streams, except where they were rejuvenated by differential movement, appears for the most part to have been low. In only a few cases are their channels exposed, and even when later streams have cut through a tongue of basalt, the exact position of the old channel is often masked by hillside slipping. There is also the possibility of small earth movements having taken place since the time when the early lava flows occupied the old valleys (4) For these reasons, and in the absence of exact measurements of height, field relations have been given the most weight in attempting to trace the course of the old streams.

THE ANCIENT BULLENGAROOK RIVER.

The tongue of basalt which runs south from Mt. Bullengarook clearly occupies an old valley. A tongue of basalt also runs north-east from Mt. Bullengarook towards the West Macedon or main branch of Jackson's Creek. A narrow gap has been cut through this tongue by the Slate Quarry Creek near Waterloo Bridge, and the position of springs at the gap indicates the bottom of the old valley.

The mapping of the area near Dohoney's Corner, as shown on Quarter Sheet 6 S.W., requires modification. In the field it is sometimes difficult to distinguish volcanic from sedimentary areas, since surface drift covers the low-lying portions of both alike, and it is probable that at the time of the survey much that is now cleared and cultivated land was heavily timbered.

In the Quarter Sheet, bedrock is shown projecting north-east from Dohoney's Corner across Sections 30 and 31. This projection is really a ridge of gravel, or gravel-capped Ordovician. At Dohoney's Corner it is higher, and at the point where it is shown as ending, a few feet lower than the top of the basalt to the west, it dips a few feet but still continues as a prominent gravel ridge until it meets the Ordovician towards Jackson's Creek. If the basalt had flowed along an east-west valley, as would be inferred from the mapping on the Quarter Sheet, we might expect to find a ridge of basalt running in that direction, instead of which we find a gravel ridge running nearly north and south.

In the absence of a topographical survey of the locality, the following statement of heights obtained by aneroid and sight level is submitted: the highest point of the basalt north of Waterloo Bridge is 65 feet above its base near the bridge. The highest point of the basalt east of the gravel ridge is level with the base of the basalt near Waterloo Bridge. The lowest part of the gravel ridge is 40 feet above the top of the basalt to the east.

The gravel ridge at the time of the lava flow was doubtless higher than it is now, but probably was not quite as high throughout its entire length as the top of the basalt to the west. It seems to have branched towards the north, and in a hollow between the branches some basalt still remains. For the reasons given above, the writer believes that the infilled valley running north-east from Mt. Bullengarook was portion of the "Ancient Bullengarook River" valley, its only possible outlet being to the south. In that case the head of Jackson's Creek was one of the head-waters of that ancient river.

The base of the basalt is exposed at the head of Dunn's Gully, between Mt. Bullengarook and Haire's Hill, and a comparison was made by aneroid of its height there with the base of the basalt near Waterloo Bridge, with the result that it was found to be higher than that near the bridge by about 70 feet.

A quarter of a mile south of, and 120 feet higher than, the low basalt in Dunn's Gully, bedrock and gravel outcrop at the surface. Bedrock outcrops on the Bacchus Marsh road, west of Mt. Bullengarook. From about the same level as this outcrop, and on the northern slope of the mount, a well has been sunk 160 feet through basalt to bedrock. This still could not have been on the old river bed, which must have been further to the east, between the well and the gravel and bedrock outcrop, or directly under the mount.

On the Quarter Sheet, about a quarter of a mile north-east of Dohoney's Corner, a tongue of basalt is shown projecting south-west across Section 30. In line with this tongue and at the same level, running south-west across the Bacchus Marsh road, there is a wide, flat-bottomed depression, and about half a mile south of the corner at a low level, an outcrop of basalt of similar type to that towards the north. This outcrop has not been noted by the Survey. About a mile still further south, at what is known as "Chapman's" there is an outlier of basalt of similar type resting on gravel.

About three-quarters of a mile west of Rosslyn, Jackson's Creek has cut through a bar of basalt, exposing an old valley, the bottom of which is about 50 feet above the present level of the creek. These three points, which are in line with the tongue of basalt in Section 30, seem clearly to mark an old stream valley. A comparison of the depth of its channel with that of the old valley to the west of the gravel ridge suggests that the eastern stream was the greater. In that case obviously its source was not towards the south. It was probably an eastern branch of the Ancient Bullengarook River, with headwaters at Lawson's Creek, and the southern portion of its course occupied nearly the present position of the Pyrete Creek. The outlier of basalt at Chapman's is probably not the base but some higher remnant of a flow. Aneroid measurements failed to show any difference in height between it, the outcrop south of Dohoney's Corner, and the base of the bar of basalt at Jackson's Creek. Of these two branches of the Ancient Bullengarook River, the western may, by the accession of tributaries from that direction, have become the greater before their junction.

THE SLATE QUARRY CREEK.

This creek was evidently a tributary of the Ancient Bullengarook River, flowing for part of its course along the northern edge of the Bullengarook gravel sheet.

THE INFILLED BRUCEDALE-LITTLE SCOTLAND VALLEY.

Its relation to the neighbouring Ordovician shows that this stream trended north, a conclusion which aneroid measurements support. The bottom of the old valley at Little Scotland is only about 30 feet above the present creek level, so that this old stream could not have been a tributary of the Ancient Bullengarook River, but must have turned towards the east.

THE INFILLED VALLEY OF MURRAY'S SPUR.

The levels of the bedrock underlying the basalt show that this old valley trended south-west. It is in a direct line with the south-west portion of the Pyrete Creek, and drained the high ground near Mt. Gisborne. The base of the basalt at the south-west end of the spur is considerably lower than the lowest part of the divide between the Pyrete and Djerriwarrh Creeks, and the infilling basalt is of an early type.

THE OLD TOOLERN CREEK.

This creek drained the country to the south and south-east of Gisborne including the area where Mt. Gisborne now stands, and that now forming the basin of the Upper Djerriwarrh Creek. To the north-west of Breakneck Hill its tributaries must have trended north for about half a mile before turning east to join the main creek. That there was no outlet for them directly to the south is shown by the absence of lava tongues in that direction. Further evidence to this effect will be given later.

THE OLD BLACK HILL CREEK.

A small stream indicated by a lava tongue seems to have run south at the Black Hill road. It probably had only a small catchment area.

PRE-BASALTIC DRAINAGE TO THE EAST OF GISBORNE.

Reconstruction of the pre-basaltic drainage in the area to the east of Gisborne is difficult, owing to the basalt covering. If, as is probable, the drainage from the Macedon Ranges took approximately the course of the present Riddell's Creek, there would have been only a small catchment area for any streams immediately to the east of Gisborne.

An interesting problem presents itself at Red Rock Hill. To the south-east of the hill, bedrock outcrops at a height of 1,500 feet. On the southern flank of the hill, about a quarter of a mile north-west of this outcrop and from about the same surface level, a bore was put down which passed through 359 feet of basalt to bedrock, so that the height of the old surface at the bottom of the bore is 1,141 feet. Somewhat less than three-quarters of a mile west of the bore, bedrock is exposed in a creek at a height of 1,400 feet. An extensive area of bedrock occurs to the north and north-west of the hill, so that the outlet from the low ground could not have been in either of these directions. Neither could it have been to the south-east or directly to the south. An outlet may have existed to the south-west, in the direction of the Calder Highway, but this is doubtful, since the bedrock outcrops not far to the east of the Highway and also to the west of the Highway, about half a mile south of Deverall's Hill at a height of about 1,400 feet. A possible direction is to the north-east, when it may have turned south towards Mt. Tophet, or have continued north-east towards Clarkefield. It seems most probable that in pre-Newer Volcanic times a stream trending east occupied a position not far from the present Jackson's Creek, but somewhat further north, united somewhere east of Clarkefield with a stream coming from the direction of Lancefield, and that with the exception of the reversal and diversion of portions of the Ancient Bullengarook River, the chief drainage lines did not differ greatly in position and direction from those of the present day.

Lakes of the Newer Basalt Period.

Evidence of the existence of lakes during the Newer Volcanic Period is to be found in the south of the area at the Djerriwarrh Creek and south of Couangalt.

A bed of a material, which has been determined by Dr. A. B. Edwards to be impure diatomaceous earth, is exposed in the gorges of the Djerriwarrh Creek and some of its eastern tributaries, interbedded with the lava flows. Owing to the basalt cover, the extent of the deposit cannot be seen, but it appears to be about half a mile in length and breadth, and several feet thick. The surface of the underlying lava slopes towards the south, and the diatomaceous bed indicates the former existence of a lake on the sloping surface. There being no outlet for the overflow from the lake across the high bedrock to the south, it probably made its way eastward along the edge of the lava to the Toolern Creek. Diatomaceous earth altered by the basalt is also exposed near the bottom of the Toolern Creek valley, about a mile south of Couangalt. At this locality there is evidence that the old valley was blocked by an early point of eruption in the valley itself. A few blocks of altered diatomaceous earth also occur in another branch of the creek, about half a mile to the west.

The Existing Streams.

Excluding a few of the minor tributaries, it is probable that all of the present streams which flow over Ordovician rocks, and which have not been influenced by the basalt, are of pre-Newer Volcanic age, while all that are associated with the basalt had their origin during the Newer Volcanic period. These Newer Volcanic streams may vary considerably in age, and some may vary in age in different parts of their course. Hassed's Creek probably came into existence soon after the commencement, and the upper portion of One Mile Creek near the close, of the volcanic period.

The Pyrete Creek has its source between Haire's Hill and Dohoney's Corner. It runs in a southerly direction for about 4 miles, and then turns sharply to the south-west, crossing the strike of the Ordovician rocks in a zig-zag fashion for more than 4 miles before turning south again on reaching the Bullengarook lava tongue. It probably follows very nearly the course of a branch of the Ancient Bullengarook River. The Slate Quarry Creek was probably a tributary of the Ancient Bullengarook River, flowing for part of its course along the northern edge of the Bullengarook gravel sheet. Goodman's Creek and Dunn's Gully, with the Lower Pyrete Creek, are laterals to the Bullengarook lava tongue. Hassed's Creek is portion of the Ancient Bullengarook River reversed by the lava flows.

Jackson's Creek.—Evidence has been brought forward that the western portion of this creek was part of the Ancient Bullengarook River, diverted to an easterly course by the Bullengarook lavas. Further east its course was determined by lava flows from points of eruption to the north and the south. Toolern Creek propably occupies nearly the position of the pre-basaltic stream, but with considerably less catchment. Where it crosses the "Gisborne Fault," from the higher to the lower block, it is not lateral to but runs for about a mile along the centre of the narrow tongue of lava. This is probably due to the formation of a depression in the lava by the draining away of the central, more plastic portion. The Eastern Branch of the Toolern Creek commences as a lateral to the lava. The gullies near Breakneck Hill are probably about the same age as the Eastern Branch of the Toolern Creek.

The *Djerriwarrh Creek.*—The lake which existed in the Djerriwarrh area ultimately found an outlet to the south, either by tapping by a gully on the Ordovician, or by the raising of its level by a later lava flow. Once the outlet was formed, rapid downward cutting through the soft diatomaceous bed and the

Ordovician gave rise to the deep gorge of the Djerriwarrh Creek, which runs for nearly a mile parallel to, and about a quarter of a mile distant from, the western edge of the basalt.

The Points of Eruption and the Lava Flows.

Mt. Bullengarook and Haire's Hill.

The earliest flow from these centres appears to have taken a north-easterly direction along a branch of the Ancient Bullengarook River. The depth—upwards of 400 feet—of the gullies lateral to the lava flow south of Mt. Bullengarook, suggests that it is of an early date. However, Cataract Gully, on the basalt, is, except near its mouth, an insignificant depression which is crossed by a road without even a culvert being necessary, and is quite comparable with streams of similar catchment near Mt. Gisborne and on the Keilor Plains.

At Mt. Gisborne the commencement of activity seems to have taken place towards the northern flank of the present hill. Later, about the middle of the volcanic period, a rounded hill which sent out lava flows in all directions, except to the north-west where high bedrock was in the way, was built up, forming the central portion of the present mount. A series of eruptions then built up the north peak, and lastly the south peak was formed. Many other points of eruption, which need not be described here, exist in the area.

Stream Capture.

The writer formerly shared the opinion that the Upper Pyrete was at one time a head gully of the Djerriwarrh Creek, and was captured by a tributary of the Ancient Bullengarook River. He has since abandoned this view for the following reasons:—

Early in the Newer Volcanic Period the south-west reach of the Pyrete Creek was already entrenched in a valley which was far below the level of the divide between the Pyrete and Djerriwarrh Creeks. The evidence for this is the unfilled valley of Murray's Spur, which must have continued in a south-west direction. Evidence has been given which suggests that in pre-volcanic times the Upper Pyrete had a much greater catchment area than the present creek has, and it is unlikely that such a stream, if early in its history it flowed south towards the Djerriwarrh Creek in line with the strike of the Ordovician rocks, would not maintain its course, or that it would be captured by a tributary of an equal stream some miles to the west. It seems more probable that the south-west reach of the Pyrete is due to the configuration of the old erosion surface, and that the creek has occupied very nearly its present position since its commencement.

The River Flats of Jackson's Creek.

Along Jackson's Creek, wherever bedrock is exposed above a bar of basalt, a flat has been formed. The most important of these flats is that at Gisborne, its greatest width being about half a mile, and its length a mile and a half. A large flat exists at Rosslyn, above the bar at Little Scotland, which has been completely cut through, so that the Rosslyn flat is continuous with that at Gibsorne. The size of the flats at Gisborne and Rosslyn is probably due, not so much to the comparatively narrow bars of basalt which have been the direct cause of their formation, as to the wide stretch of basalt which the creek enters upon about half a mile east of Gisborne, and which has prevented the creek from reaching a sufficiently low level to breach the bars by undercutting. Waterloo Flat formed while the Slate Quarry Creek was cutting through the bar of basalt near Waterloo Bridge. This bar is now completely cut through. About a mile west of Rosslyn the remnant of a small terrace exists about 50 feet above creek level. This was probably a flat formed while the creek was cutting through the bar of basalt which it crossed at that point. To the east of the mouth of One Mile Creek a flat, several acres in extent, occurs in volcanic rock. The light scoriaceous nature of the rock, and the presence of beds of unconsolidated volcanic material, indicate that this was probably a point of eruption.

Some General Remarks.

It is difficult to decide when the evolution of the present topography began. It probably had its beginning long prior to the end of the last great erosion period. The Macedon Ranges, which lie to the north-east of the area particularly dealt with, have existed for a very long time as a prominent mountain mass. The course of a pre-basaltic stream was approximately that of the present Riddell's Creek (5). At that time this was probably the most important stream in the eastern area, and its basin seems to have extended in width approximately to a line from Gisborne to Sunbury. Acting, as it may have done, through a very long period of time, it would have an important effect in the development of the pre-basaltic topography.

The bedrock, which here and there rises above the basalt between Gisborne and Sunbury and between Mt. Tophet and Clarkefield, consists almost wholly of the hard sandstones and quartzites and the hardened shale beds of the "Riddell Grits" (2), and it is probable that these high areas of bedrock are due to their resistance to erosion and not to the Tertiary earth movements which affected the western portion of the Gisborne district.

No drift wood or fossils of any kind have been noticed in the Bullengarook gravels. It is probable that climatic conditions played an all-important part in their formation, and it is possible that the elevation of the main divide may have preceded the formation of the gravels by a long period. If this period had been greatly prolonged, however, there should be more distinct evidence of the existence of well-developed drainage lines in the area at the time of formation of the gravels.

If recent earth movements of appreciable magnitude have occurred, there should be rejuvenation of the streams and consequent rapid erosion in the areas affected. In the Gisborne flat, where beds of clay, sand, and gravel containing basalt pebbles occur, much work is being done by Jackson's Creek, by side-swinging, with but slight lowering of its bed. The same creek near Rosslyn has worn a particularly deep and steep-sided channel, which may be accounted for by the cuttng through of the bar of basalt at Little Scotland.

In places along some of the tributaries of the Pyrete and Djerriwarrh Creeks, a great deal of material has been removed quite recently. This material consisted chiefly of soil and fragments of rock from the hillsides, which had accumulated in the gully, so that the work done represents the widening rather than the deepening of the valley.

Toolern Creek, on its passage from the higher to the lower block, has worn a deep channel with projecting points of basalt with vertical walls and many fallen blocks. Above these points there are usually small flats at creek level, the occurrence of which on such a small stream shows that downward cutting has been slow and probably normal under existing conditions of grade and rock structure.

The most striking case of rapid erosion occurs near the mouth of Cataract Gully, where there are vertical columns of basalt 60 or 70 feet high, and the creek bed is littered with fallen blocks. This is doubtless due to the creek having reached the underlying gravel beds of the old Bullengarook River, and it seems probable that in the area dealt with, no appreciable earth movements have occurred since the commencement of the Newer Volcanic Period, and that the forces now acting are those of erosion only.

This statement is not intended to apply to the Coimadai area, which has not been closely examined. The writer has long suspected that the Coimadai limestone was derived from the Mt. Bullengarook lava, being led to that opinion by the abundant calcium carbonate in the cavities and associated with the basalt south of Mt. Bullengarook. The existence of the limestone basin adjacent to the lava stream is more difficult to account for.

Summary.

Gravels, referred to here as the Bullengarook gravels, cover a much more extensive area in the Gisborne Highlands than is suggested by the Quarter Sheets of the Geological Survey. The extreme dimensions of the gravel area are about 7 miles east to west, and 4 miles north to south, with a thickness of from 60 to 80 feet. The pebbles and boulders are unsorted and up to 2 feet in diameter. They range from angular to completely rounded, and consist essentially of reef quartz, quartzite, and sandstone. They occur in the form of a sheet, covering the bedrock except where intersected by the lava-filled valleys of old streams. The gravel came from the north, indicating uplift in the direction of the Main Divide, with a change of grade at the northern edge of the gravel sheet, associated with torrential floods in excess of any experienced at the present day.

In other parts of the area the surface is composed of widespread flows of volcanic rock, younger than the gravels. The old erosion surface underlying the gravels and volcanic rocks appears to have consisted of wide, almost flat areas with prominent hills and ridges here and there, dominated by the monadnock of the Macedon Ranges to the north.

The southern limit of the Gisborne Highlands is marked by a line of differential movement, which raised it above the basalt plains to the south. This differential movement occurred subsequently to the uplift of the Main Divide, but prior to the extrusion of the volcanic rocks.

The lava flows have largely obliterated the pre-basaltic drainage system, but it seems probable that the chief drainage lines did not differ greatly in position and direction from those of the present day.

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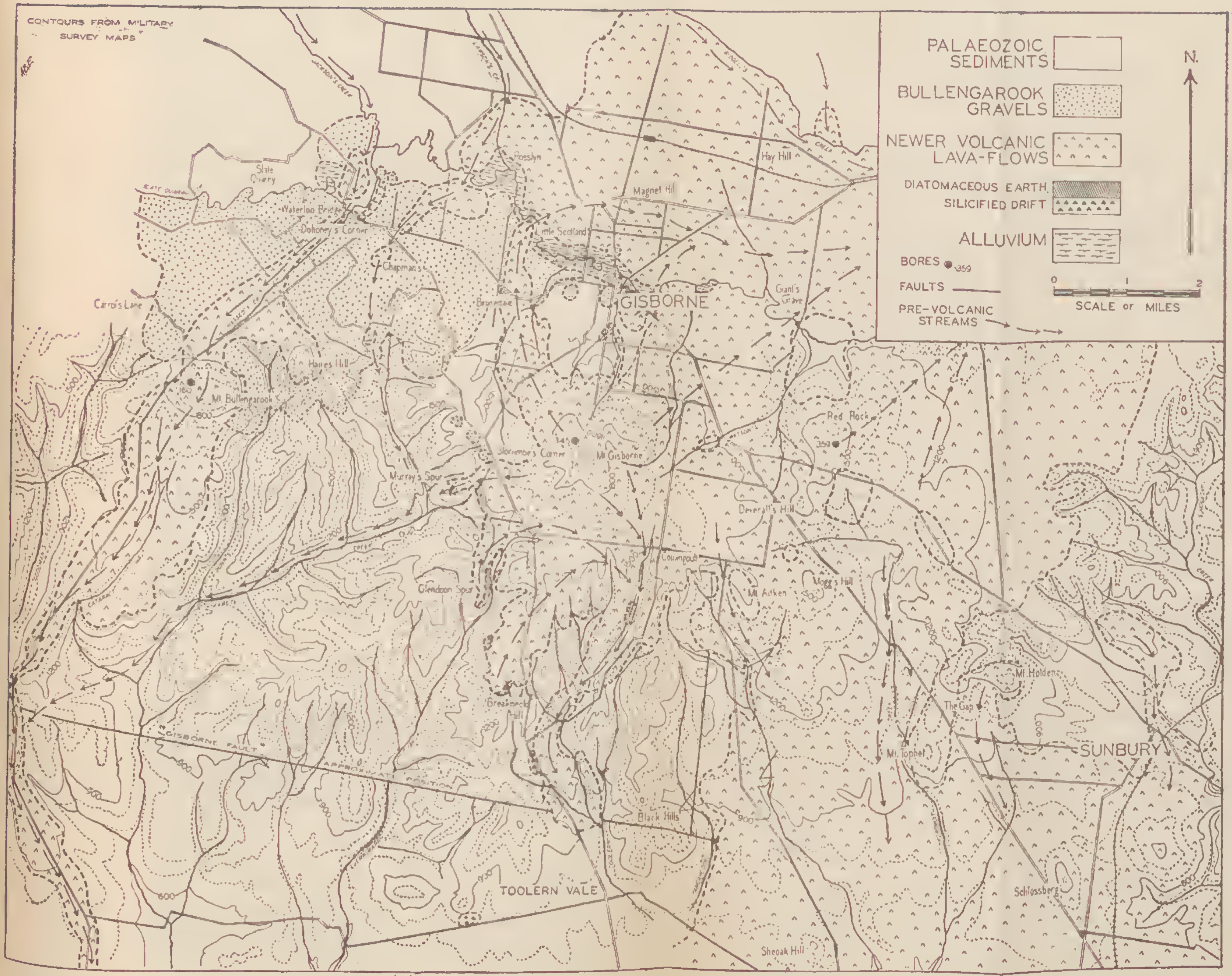

Fig. 1.—Locality Map (see Crawford's Paper).